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C.G.W. PROPRIETARY

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CORNING GLASS WORKS
ELECTRO-OPTICS LABORATORY
RALEIGH, NORTH CAROLINA

IMPROVED SCREEN FOR REAR PROJECTION VIEWERS

Technical Report No. - 21

Date - April 28, 1967

Period Covered - March 31, 1967
to
April 28, 1967

25X1
25X1

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ABSTRACT

This report summarizes the optical properties of additional samples of Corning Glass Works materials. One series of samples displayed the best optical properties obtained thus far.

Those Corning materials which have been previously rejected as unsuitable screen materials were reevaluated. Their poor performance was primarily caused by improper particle size, and for this reason some glass-crystal systems were found to be unsuitable for fabricating further samples.

Additional 8" x 10" Fotoform[®] screens are being fabricated, with precautions being taken to ensure flat samples.

Techniques have been found which give sturdy, uniform beaded screens. Some prototype 8" x 10" screens are to be fabricated next period.

Work was completed on several new lenticular plates which will be redrawn into ribbon.

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TECHNICAL REPORT NO. 21

I. Screen Materials

A. New Materials

Measurements have been completed on 53 new samples of glass-ceramic screen materials, and the results are summarized in Table 1 of Appendix A. Curves of T_{45} and R_d vs. axial gain are also contained in Appendix A, and detailed data consisting of tabulated values of gain (K) and gain curves for the materials are presented in Appendix B.

Many of the samples of the BA and BC series are unsuitable as screen materials because of excessive specular transmittance caused by insufficient number density of particles and/or because the particle size was too great. The BB series, however, are some of the best materials obtained thus far. These materials generally exhibited brightness variations well within acceptable limits and had zero specular transmittance, as opposed to specular transmittance in the red which was present in many earlier samples. The measured T_{45} values of the BB series are slightly lower than the predicted theoretical values, probably because the particle concentrations are slightly greater than optimum. Photomicrographs will be made to verify this and to determine the crystal size.

The measured diffuse reflectances of some selected samples are plotted on a theoretical curve of R_d vs. axial gain, Figure 4. The measured values are in good agreement with theory, with a few exceptions. The reason that the BA-4A and BA-5A samples have R_d 's much less than theory predicts and still have reasonable values of T_{45} is not completely understood, but is felt to be significant. More samples of this type will be requested, and photomicrographs will be made in order to determine particle size and concentration.

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B. Previously Rejected Materials

Those Corning materials which have been tested and rejected as unsuitable screen materials were re-evaluated in order to determine the reasons for their poor performance. It was found that the scattering particles were too small in some materials, while some of the other glass-ceramics which have low-index particles ($n = 1.3$) in a high-index glass ($n = 2.0$) had an excessively large number density of particles. Those materials which consistently gave good screens are from the same glass-crystal system.

II. Screen Fabrication

A. Thin-Layer Fotoform[®] Glass Screens

Additional 8" x 10" Fotoform[®] screens are being fabricated. Different surface preparation will be used in an effort to eliminate any buckling, and the heat treatment will be altered to obtain a thicker scattering layer. Other precautions will be taken to insure flat, uniform screens. These prototypes will be discussed in the next period report.

B. Beaded Screens

Sturdy, uniform beaded screens have been made by spinning a plastic layer onto a glass substrate and then pressing the coated substrate into a bed of glass beads.

A small quantity of high-index ($n = 1.97$) beads has been received. Screens made from these beads have very uniform viewing characteristics over a wide viewing angle. We have also obtained an extremely small amount of beads having index 2.3 - 2.4. These will allow the optimum ratio of plastic and bead indices, $n_1/n_2 = 0.6$.

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However, the high absorption of these beads and the difficulty in obtaining them may render them impractical for rear projection screen applications.

Some 8" x 10" prototype beaded screens will be fabricated and discussed in the next period report.

C. Lenticular Plates

Work was completed on several glass plates having triangular lenticules ground into their surfaces. These plates will be redrawn into lenticular ribbon, which can be used to control the viewing properties of glass-ceramic screens.

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APPENDIX A

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Table 1

Summary of the Optical Properties of
Some Corning Glass Works Materials

Sample Code	T _s (%)	T ₄₅ (%)	T _{spec} (%)	Axial Gain	Brightness Variation ±45° (%)	Thickness (mm)
BA-1A	42	16	0	1.2	8	1.06
BA-3A	68	50	0	15.	87	.992
BA-3B	74	68	.24	59.	98	.508
BA-4A	51	21	0	1.7	13	1.05
BA-5A	46	17	0	1.2	3	1.05
BB-1A	65	26	0	2.4	21	.378
BB-1B	55	21	0	1.5	4	.858
BB-2A	69	30	0	3.3	33	.358
BB-2B	57	22	0	1.6	4	.828
BB-5A	52	21	0	1.5	8	.358
BB-5B	37	14	0	1	5	.869
BB-6B	36	14	0	1	3	.88
BB-7A	62	25	0	2.2	19	.335
BB-7B	48	18	0	1.3	5	.856
BB-8A	54	21	0	1.6	8	.337
BB-8B	39	15	0	1.1	9	.86
BB-10A	60	24	0	2.3	22	.35
BB-10B	43	16	0	1.2	6	.868
BB-11A	55	21	0	1.7	10	.349
BB-13B	31	12	0	0.9	3	.88
BB-14A	71	32	0	5.9	58	.338
BB-14B	56	22	0	1.7	8	.873
BB-16A	81	36	0	3.4	26	.33
BB-16B	61	23	0	1.7	6	.86
BB-17A	67	28	0	3	30	.332
BB-17B	53	20	0	1.4	5	.854
BB-18A	73	35	0	6.2	60	.378
BB-18B	57	22	0	1.8	10	.871

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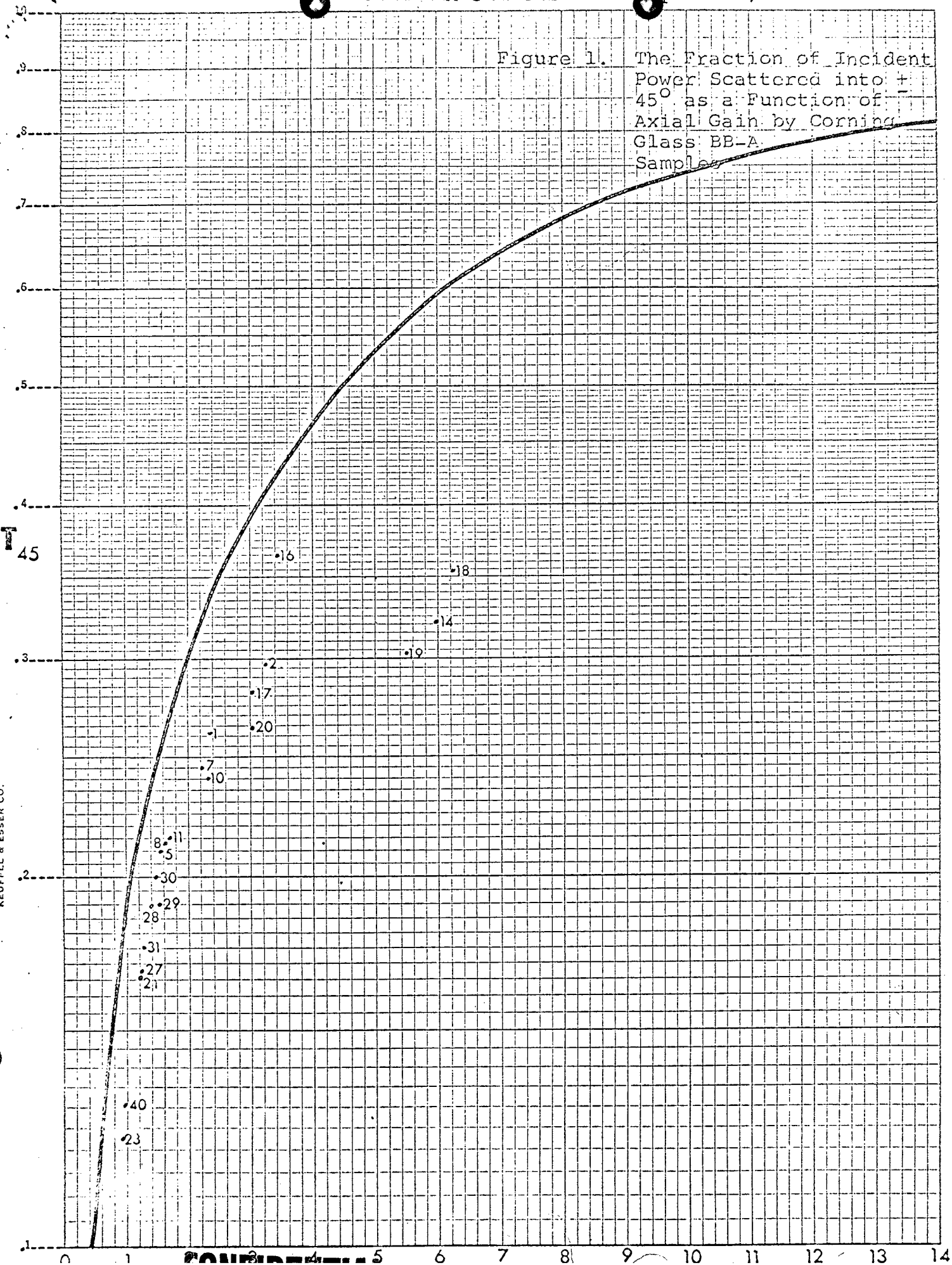
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Table 1. (continued)

Sample Code	T _s (%)	T ₄₅ (%)	T _{spec} (%)	Axial Gain	Brightness Variation ±45° (%)	Thickness (mm)
BB-19A	67	30	0	5.5	55	.344
BB-19B	49	20	0	1.4	6	.892
BB-20B	58	26	0	3	37	.878
BB-21A	44	16	0	1.2	4	.377
BB-21B	29	11	0	.8	5	.882
BB-22B	29	12	0	.8	5	.857
BB-23A	33	12	0	.9	6	.398
BB-23B	24	9	0	.6	3	.81
BB-26B	29	11	0	.8	3	.35
BB-27A	43	17	0	1.2	5	.38
BB-27B	34	13	0	1	5	.867
BB-28A	50	19	0	1.4	4	.352
BB-28B	33	12	0	.9	3	.858
BB-29A	50	19	0	1.5	9	.34
BB-29B	34	13	0	1	5	.89
BB-30A	54	20	0	1.5	6	.298
BB-30B	36	13	0	.9	4	.877
BB-31A	47	17	0	1.3	3	.363
BB-40A	35	13	0	.9	4	.4
BB-40B	26	10	0	.7	6	.894
BC-1A	60	21	4.3	1.9	13	.292
BC-1B	54	22	7.1	1.7	11	.31
BC-1C	74	31	0	2.6	16	.278
BC-1D	66	26	0	1.9	7	.391

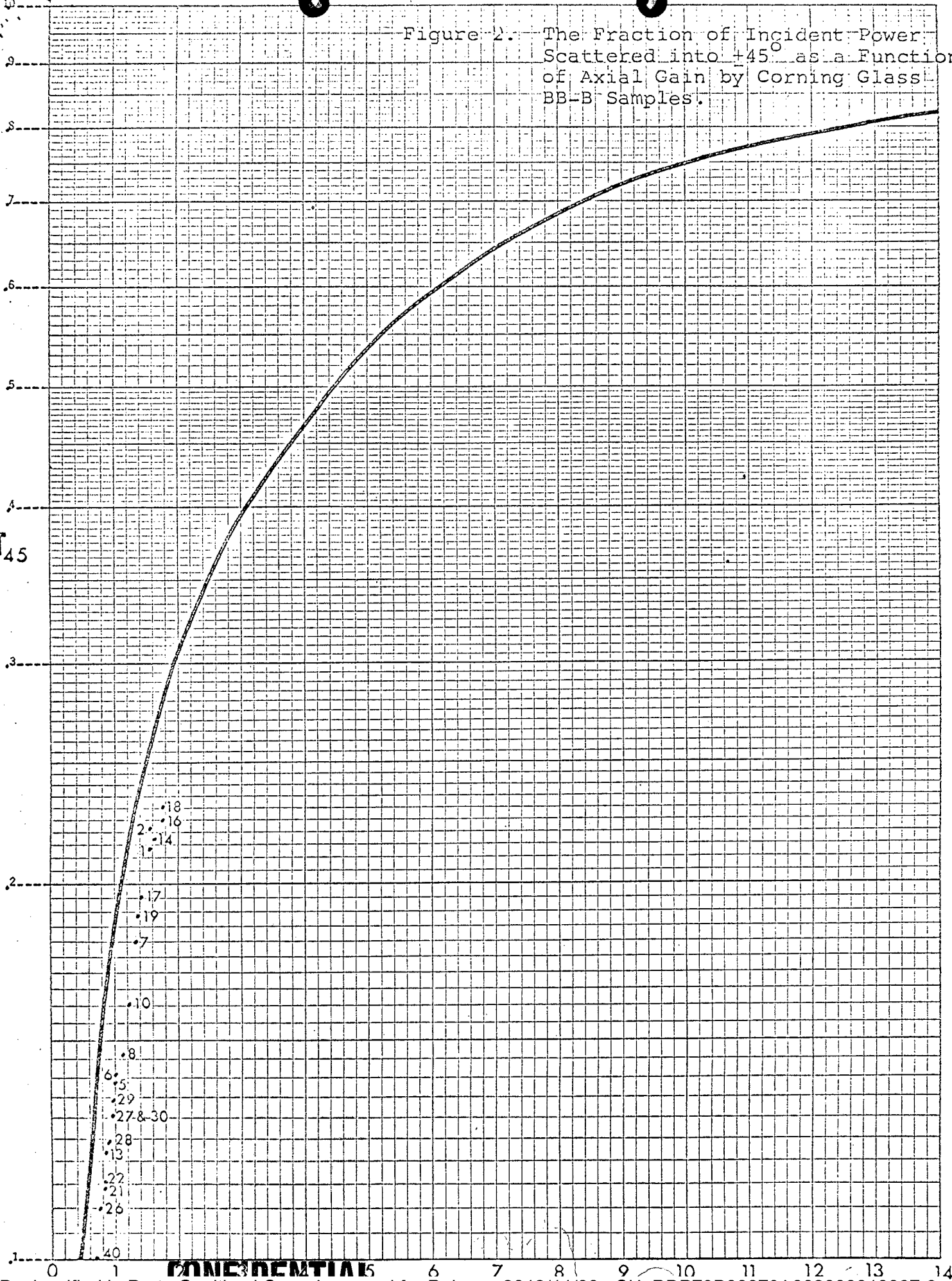
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46 4650
MADE IN U.S.A.
KEUFFEL & ESSER CO.
1 CYCLE X 70 DIVISIONS
SEMI-LOGARITHMIC

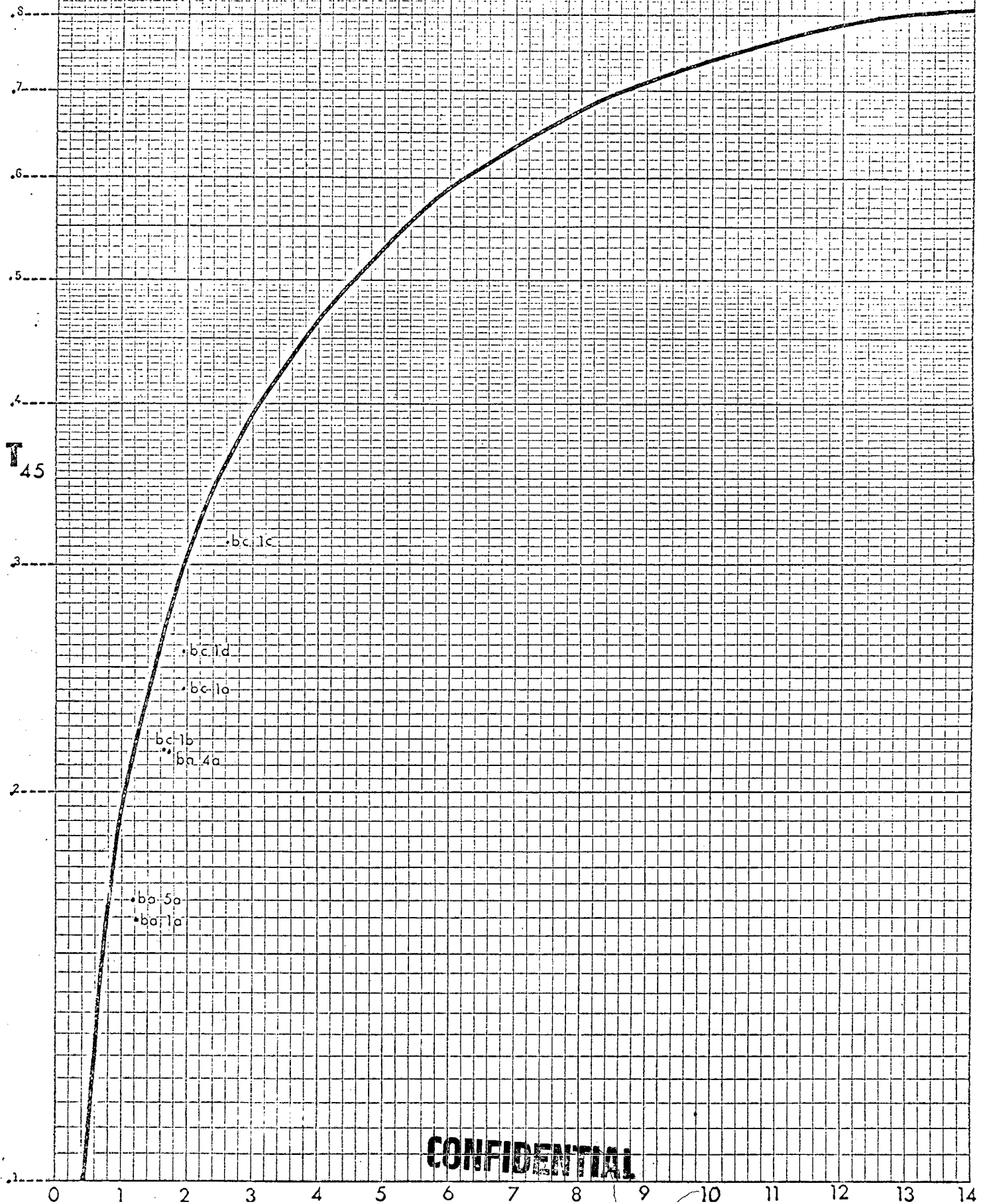
Figure 2. The Fraction of Incident Power Scattered into $+45^\circ$ as a Function of Axial Gain by Corning Glass BB-B Samples.

T_{45}



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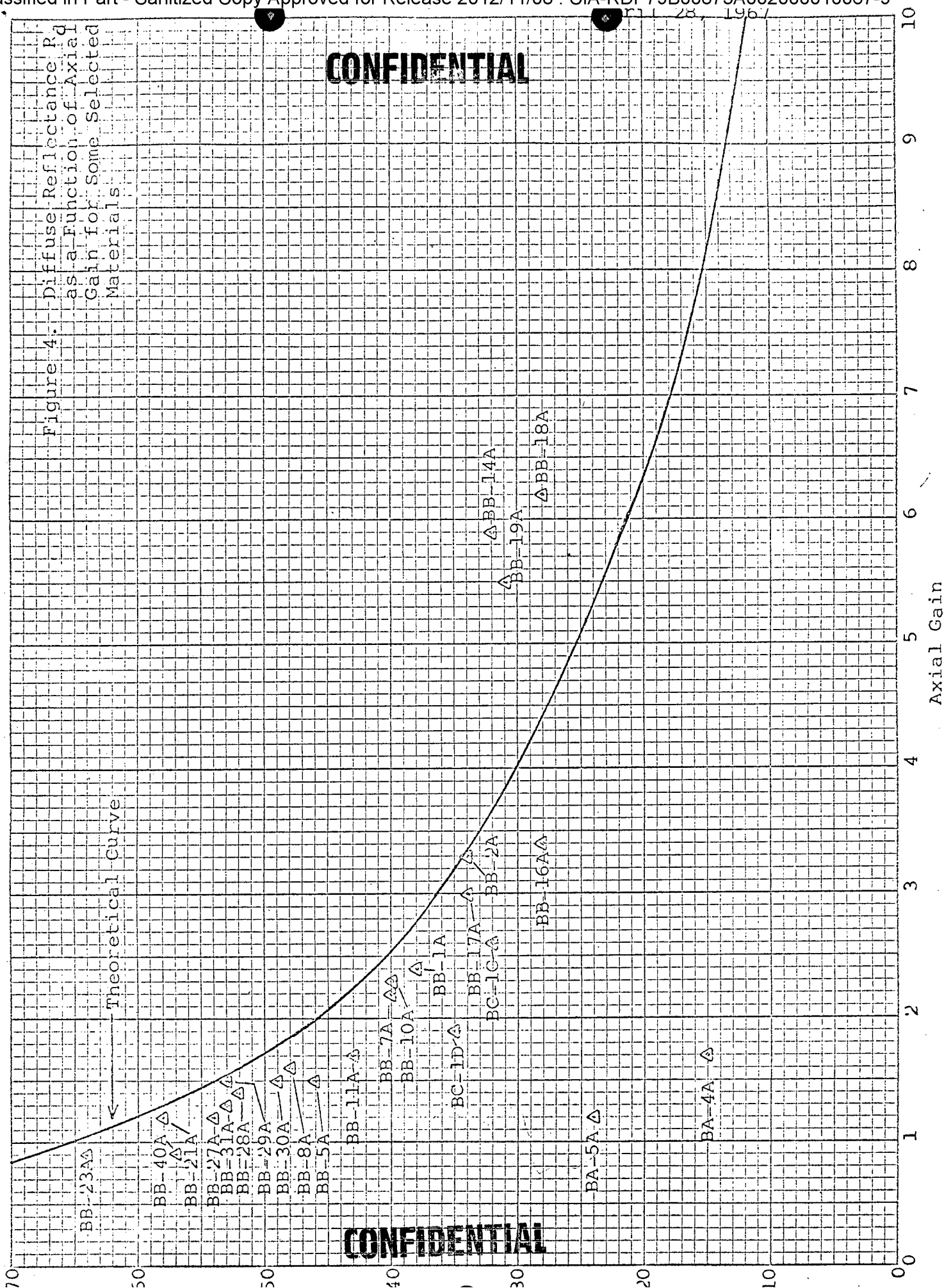
Figure 3. The Fraction of Incident Power Scattered into $\pm 45^\circ$ as a Function of Axial Gain for some Corning Glass Materials.



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Figure 4. Diffuse Reflectance ρ_d as a Function of Axial Gain for Some Selected Materials

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APPENDIX B

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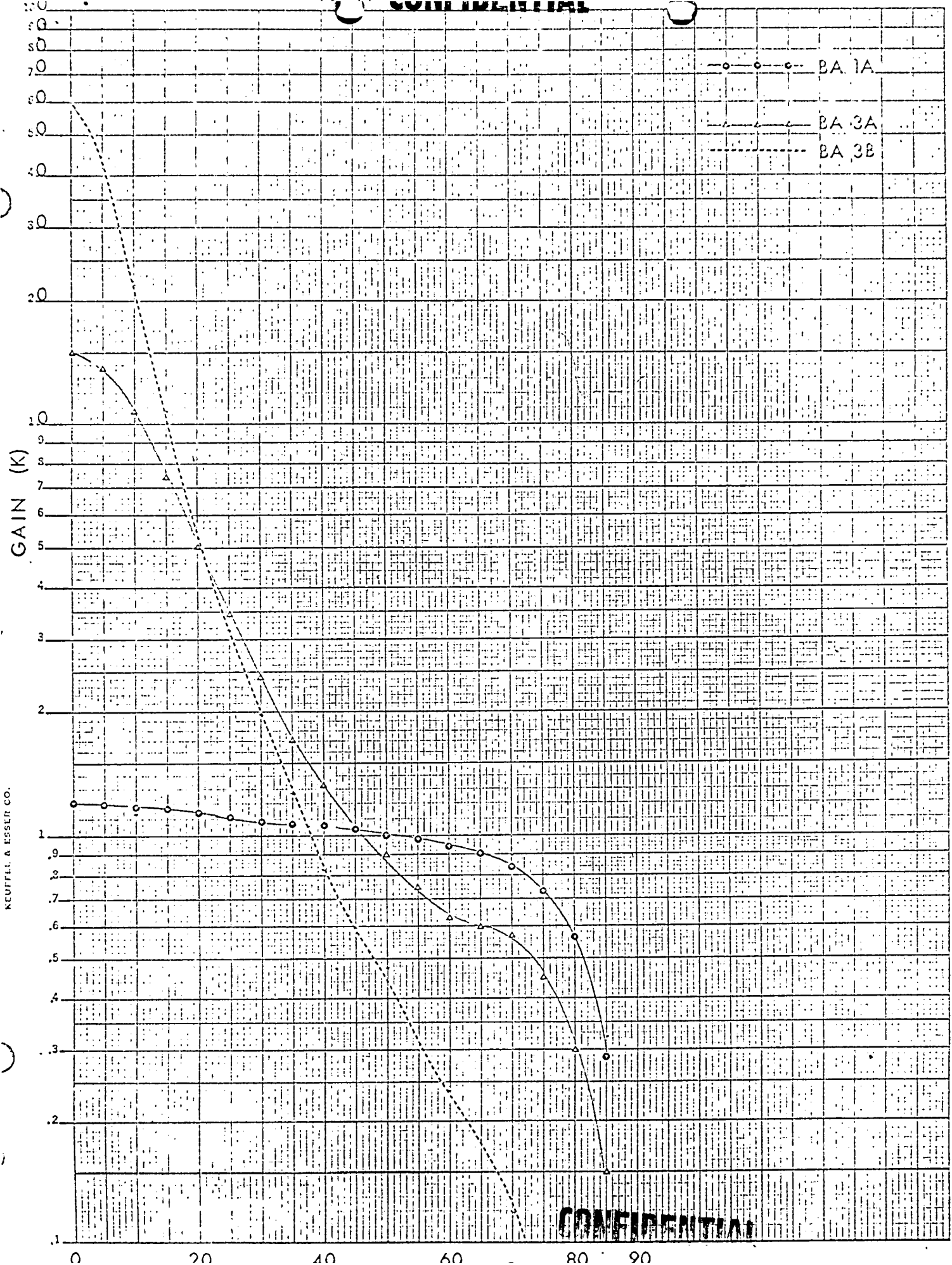
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SUMMARY OF ANGULAR GAIN FUNCTIONS.

ANGLE K	BA-1A	BA-2A	BA-3A	BA-3B
0	1.21	292.78	14.96	59.25
5	1.19	1.78	13.61	42.37
10	1.17	1.39	10.62	21.92
15	1.14	1.06	7.48	10.07
20	1.13	1.06	5.01	5.33
25	1.1	1.06	3.44	3.14
30	1.08	1.06	2.41	1.95
35	1.06	1.06	1.7	1.24
40	1.05	1.06	1.32	.83
45	1.03	1.06	1.05	.59
50	1	1.06	.9	.47
55	.98	1.06	.75	.3
60	.94	1.06	.63	.24
65	.9	1.02	.6	.18
70	.84	.89	.57	.12
75	.73	.84	.45	.06
80	.56	.67	.3	0
85	.28	.32	.15	0
90	0	0	0	0

TS	.4164	.4432	.6851	.7436
T45	.159	.159	.503	.685
TSP	.0006	.0708	.0004	.0024
V45	.081	.993	.869	.98
ABS				

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SUMMARY OF ANGULAR GAIN FUNCTIONS.

ANGLE K	SAMPLE CODES			
	BA-4A	BA-5A		
0	1.71	1.19	0	0
5	1.67	1.18	0	0
10	1.65	1.17	0	0
15	1.61	1.17	0	0
20	1.56	1.16	0	0
25	1.52	1.15	0	0
30	1.48	1.14	0	0
35	1.43	1.13	0	0
40	1.37	1.13	0	0
45	1.31	1.12	0	0
50	1.25	1.11	0	0
55	1.18	1.09	0	0
60	1.09	1.06	0	0
65	.99	1.01	0	0
70	.88	.93	0	0
75	.74	.83	0	0
80	.58	.66	0	0
85	.34	.35	0	0
90	0	0	0	0
=====				
TS	.507	.458	0	0
T45	.215	.167	0	0
TSP	0	0	0	0
V45	.132	.029	0	0
ABS				

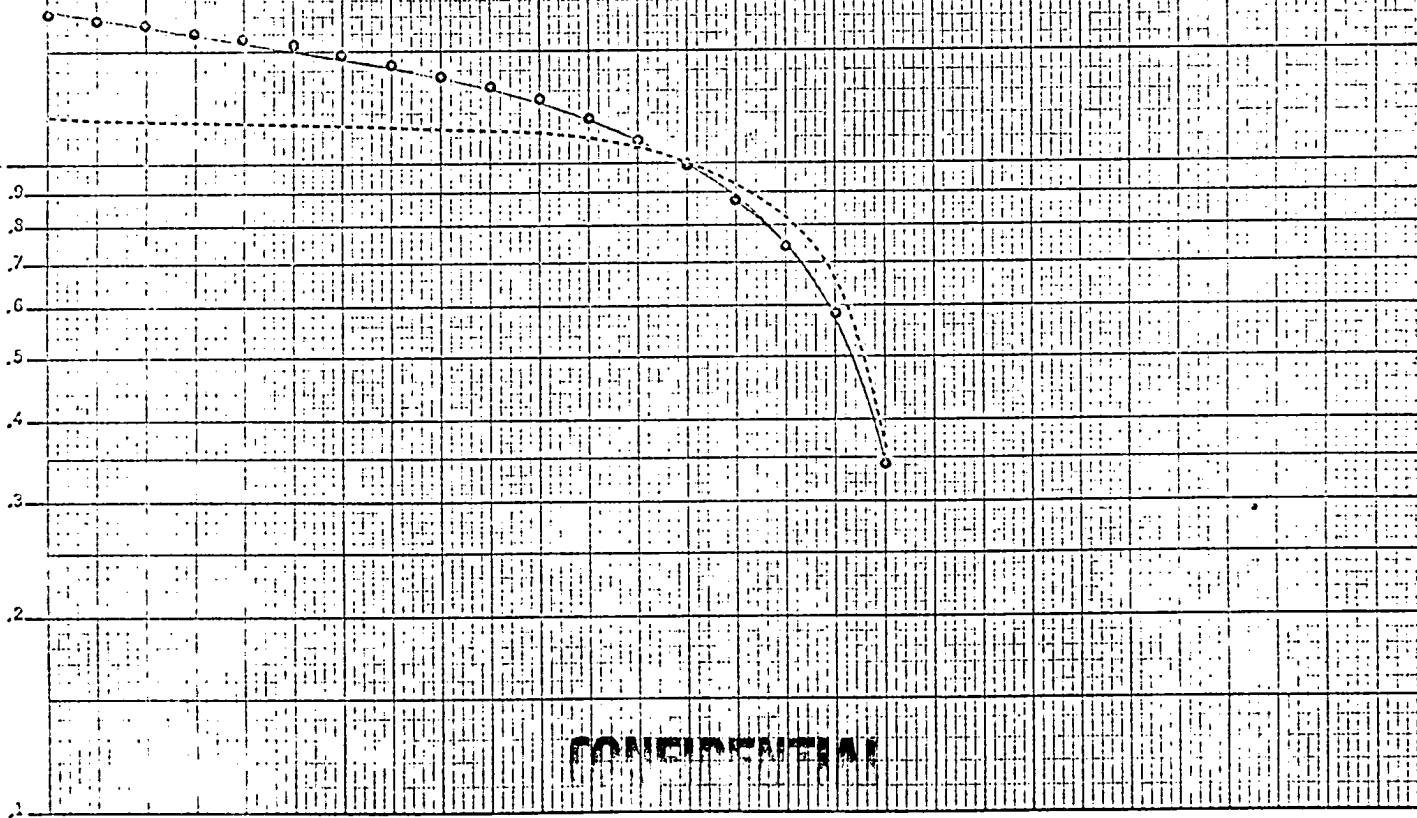
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BA 4A
BA 5A

GAIN (K)

4G 5810
SEMI-LOGARITHMIC
3 CYCLES X 140 DIVISIONS
KEUFFEL & ESSER CO.



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SUMMARY OF ANGULAR GAIN FUNCTIONS.

ANGLE K	SAMPLE CODES			
	BB-1A	BB-1B	BB-2A	BB-2B
0	2.35	1.52	3.26	1.58
5	2.33	1.51	3.07	1.58
10	2.23	1.5	2.84	1.57
15	2.1	1.49	2.57	1.57
20	1.97	1.48	2.31	1.55
25	1.84	1.47	2.1	1.54
30	1.75	1.46	1.93	1.53
35	1.67	1.45	1.83	1.51
40	1.61	1.43	1.73	1.48
45	1.55	1.4	1.65	1.45
50	1.5	1.37	1.6	1.41
55	1.46	1.33	1.54	1.38
60	1.42	1.27	1.48	1.32
65	1.37	1.21	1.4	1.26
70	1.25	1.13	1.3	1.18
75	1.09	.98	1.13	1.03
80	.85	.69	.87	.79
85	.33	.15	.2	.16
90	0	0	0	0
=====				
TS	.646	.548	.6899	.574
T45	.2 62	.213	.298	.222
TSP	0	0	.0001	0
V45	.2 13	.039	.329	.044

ABS

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BB-1A

BB-1B

BB-2A

BB-2B

GAIN (K)

40 SBT
K₀ SEMILOGARITHMIC
3 CYCLES X 140 DIVISIONS
MADE IN U.S.A.
KEUFFEL & ESSER CO.**CONFIDENTIAL**

0 20 40 60 80 90 Δ

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SUMMARY OF ANGULAR GAIN FUNCTIONS.

ANGLE K	BB-5A	SAMPLE CODES BB-5B	BB-6B	BB-7A
0	1.55	1	1.01	2.22
5	1.54	1	1	2.1
10	1.53	.99	1	1.99
15	1.51	.99	.99	1.88
20	1.49	.98	.99	1.78
25	1.47	.96	.98	1.71
30	1.44	.95	.97	1.66
35	1.42	.93	.97	1.61
40	1.38	.91	.96	1.56
45	1.31	.9	.95	1.51
50	1.3	.89	.93	1.47
55	1.23	.87	.9	1.43
60	1.16	.84	.86	1.38
65	1.08	.8	.8	1.3
70	1	.76	.71	1.2
75	.9	.67	.59	1.03
80	.71	.49	.38	.75
85	.25	.22	.05	.41
90	0	0	0	0

TS	.524	.366	.357	.616
T45	.21	.138	.142	.246
TSP	0	0	0	0
V45	.084	.051	.03	.19
ABS				

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BB 5A
BB 5B
BB 6B
BB 7A

GAIN (K)

3 CYCLES X 140 DIVISIONS
KEUTEL & ESSER CO.

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SUMMARY OF ANGULAR GAIN FUNCTIONS.

ANGLE K	SAMPLE CODES			
	BB-7B	BB-8A	BB-8B	BB-10A
0	1.32	1.62	1.14	2.31
5	1.31	1.58	1.11	2.21
10	1.3	1.55	1.08	2.06
15	1.28	1.52	1.05	1.9
20	1.27	1.5	1.03	1.75
25	1.25	1.47	1.01	1.66
30	1.24	1.45	1	1.6
35	1.23	1.43	.99	1.55
40	1.21	1.41	.97	1.52
45	1.19	1.39	.95	1.48
50	1.16	1.36	.93	1.44
55	1.13	1.32	.91	1.4
60	1.1	1.29	.88	1.34
65	1.04	1.24	.84	1.27
70	.98	1.15	.79	1.17
75	.87	.99	.69	1.04
80	.64	.65	.53	.78
85	.2 3	.08	.22	.38
90	0	0	0	0

TS	.4 76	.545	.386	.605
T45	.1 31	.213	.147	.241
TSP	0	0	0	0
V45	.053	.077	.09	.217
A2S				

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BB 7B
BB 8A
BB 8B
BB 10A

GAIN (K)

3 CYCLES X 140 DIVISIONS
KEUFFEL & ESSER CO.

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SUMMARY OF ANGULAR GAIN FUNCTIONS.

ANGLE K	SAMPLE CODES			
	BB-10B	BB-11A	BB-13B	BB-14A
0	1.21	1.7	.86	5.93
5	1.2	1.67	.86	5.23
10	1.18	1.62	.86	4.3
15	1.17	1.57	.85	3.33
20	1.14	1.52	.85	2.51
25	1.11	1.47	.85	2.09
30	1.1	1.44	.84	1.84
35	1.09	1.43	.83	1.75
40	1.08	1.42	.82	1.66
45	1.08	1.39	.81	1.57
50	1.05	1.36	.79	1.54
55	1.02	1.33	.77	1.47
60	.98	1.28	.74	1.41
65	.93	1.21	.69	1.3
70	.86	1.12	.63	1.19
75	.77	.99	.54	1.13
80	.56	.73	.43	.85
85	.25	.24	.07	.47
90	0	0	0	0

TS	.427	.555	.314	.7078
T45	.162	.215	.122	.321
TSP	0	0	0	.0002
V45	.057	.1	.033	.581
ABS				

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BB 10B

BB 11A

BB 13B

BB 14A

GAIN (K)

REG 3 CYCLES X 1.50 DIVISIONS
NEUFEL & ESSER CO.

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SUMMARY OF ANGULAR GAIN FUNCTIONS.

ANGLE K	SAMPLE CODES			
	BB-14B	BB-16A	BB-16B	BB-17A
0	1.66	3.43	1.72	3.05
5	1.63	3.36	1.69	2.8
10	1.61	3.23	1.67	2.57
15	1.58	3.05	1.65	2.36
20	1.54	2.85	1.63	2.17
25	1.51	2.64	1.6	2
30	1.48	2.46	1.58	1.86
35	1.45	2.27	1.56	1.76
40	1.42	2.13	1.53	1.69
45	1.4	2.02	1.52	1.64
50	1.38	1.91	1.49	1.58
55	1.34	1.78	1.47	1.51
60	1.29	1.68	1.44	1.44
65	1.22	1.57	1.36	1.36
70	1.12	1.41	1.23	1.26
75	.96	1.23	1.06	1.11
80	.73	.89	.85	.8
85	.33	.27	.32	.23
90	0	0	0	0

TS	.562	.8091	.611	.6669
T45	.217	.365	.231	.283
TSP	0	.0001	0	.0001
V45	.084	.258	.062	.301

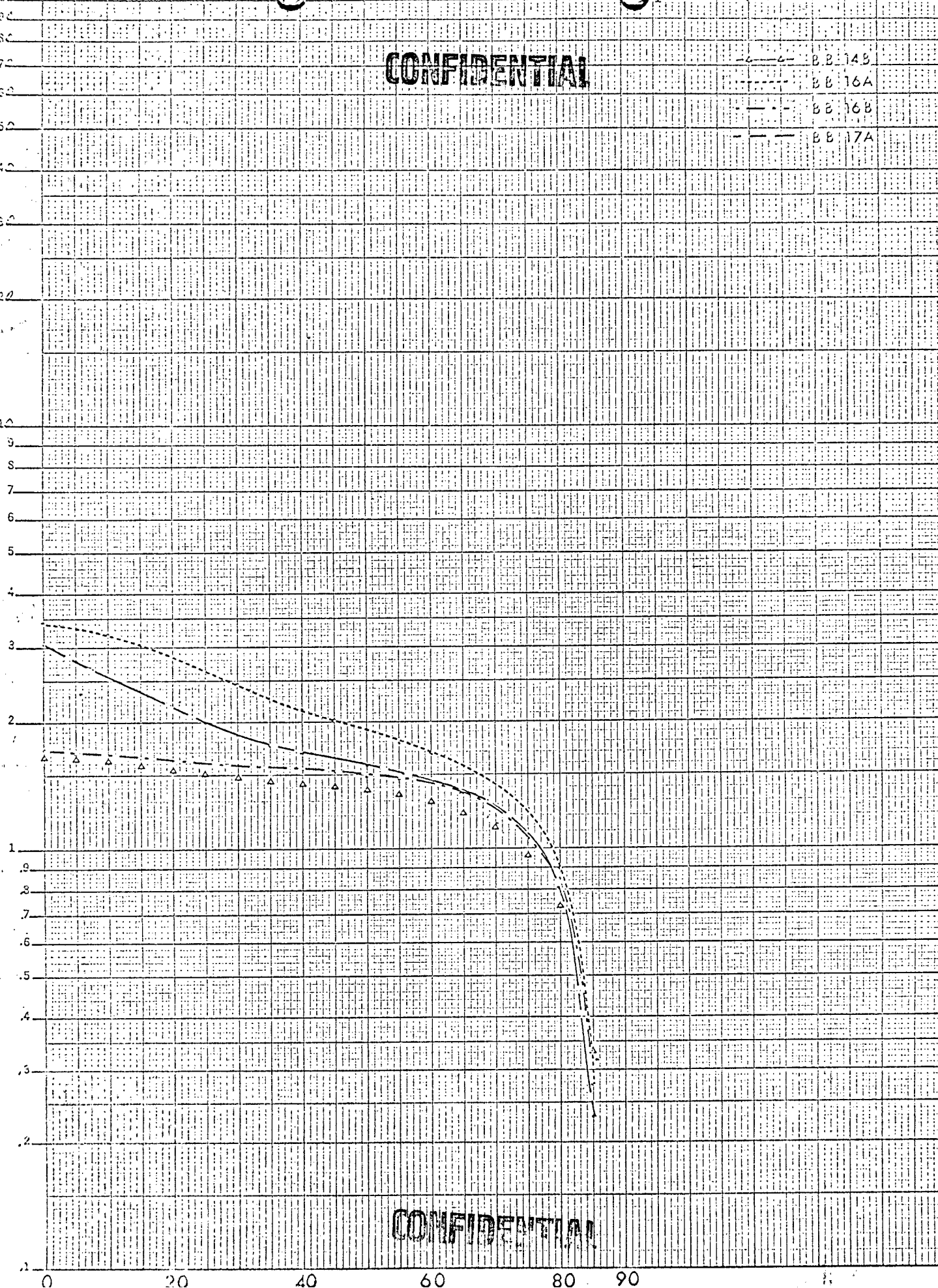
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GAIN (K)

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SUMMARY OF ANGULAR GAIN FUNCTIONS.

ANGLE K	SAMPLE CODES			
	BB-17B	BB-18A	BB-18B	BB-19A
0	1.42	6.21	1.76	5.49
5	1.41	5.81	1.74	4.75
10	1.39	4.91	1.71	3.74
15	1.38	3.88	1.66	2.86
20	1.37	2.98	1.61	2.3
25	1.35	2.42	1.57	1.99
30	1.34	2.08	1.53	1.81
35	1.32	1.83	1.5	1.72
40	1.31	1.66	1.46	1.65
45	1.29	1.55	1.43	1.59
50	1.26	1.49	1.39	1.51
55	1.23	1.43	1.34	1.43
60	1.19	1.37	1.28	1.37
65	1.13	1.3	1.2	1.32
70	1.06	1.18	1.1	1.2
75	.97	1.02	.96	1.04
80	.78	.91	.71	.73
85	.44	.43	.33	.33
90	0	0	0	0

=====				
TS	.528	.7268	.568	.6738
T45	.196	.354	.225	.303
TSP	0	.0002	0	.0002
V45	.051	.6	.105	.55

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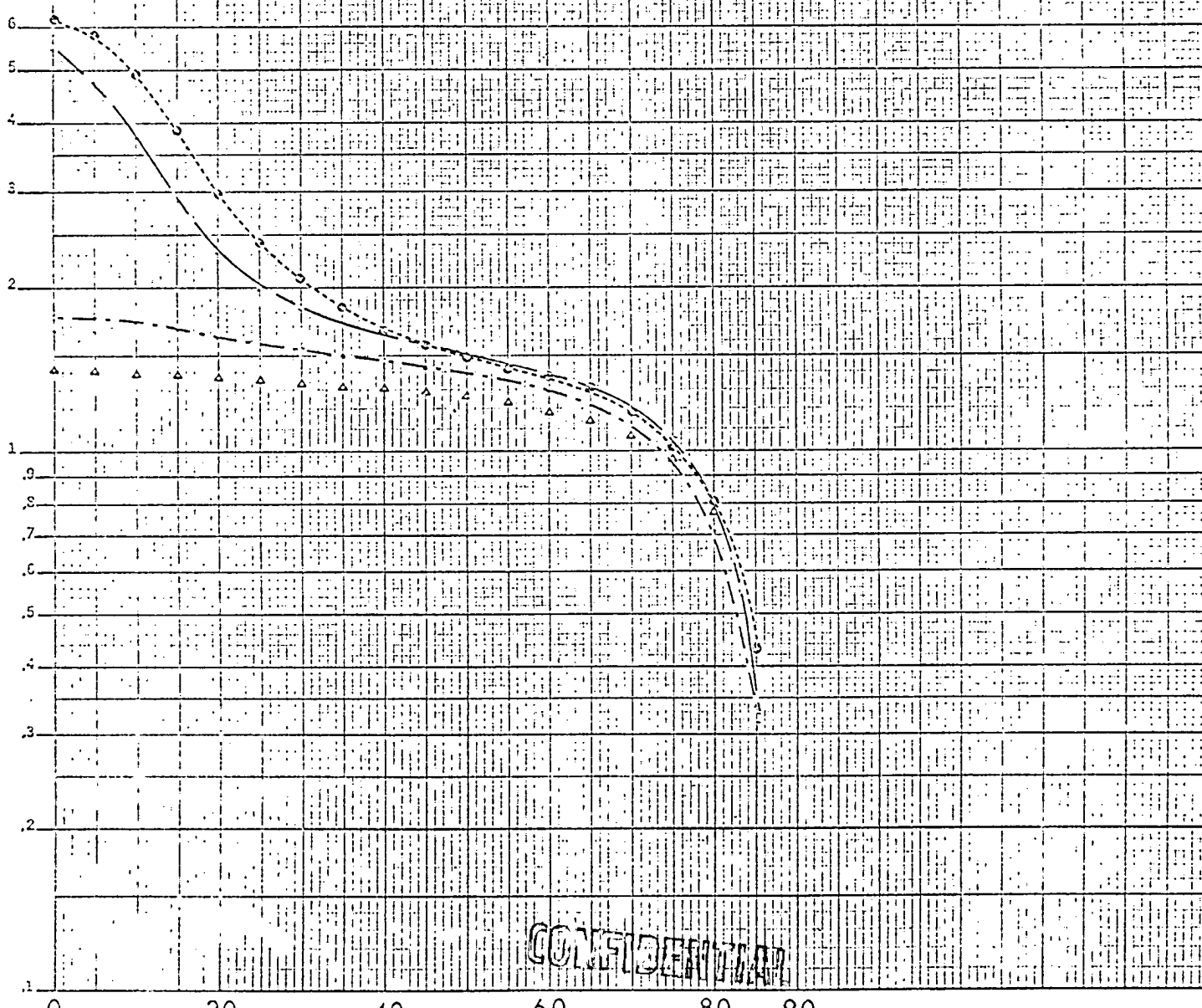
APR 11 28, 1967

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BB 172
BB 18A
BB 18E
BB 19A

GAIN (K)

46 5810
SEMI-LOGARITHMIC
3 CYCLES X 120 DIVISIONS
KEUFFEL & ESSER CO.



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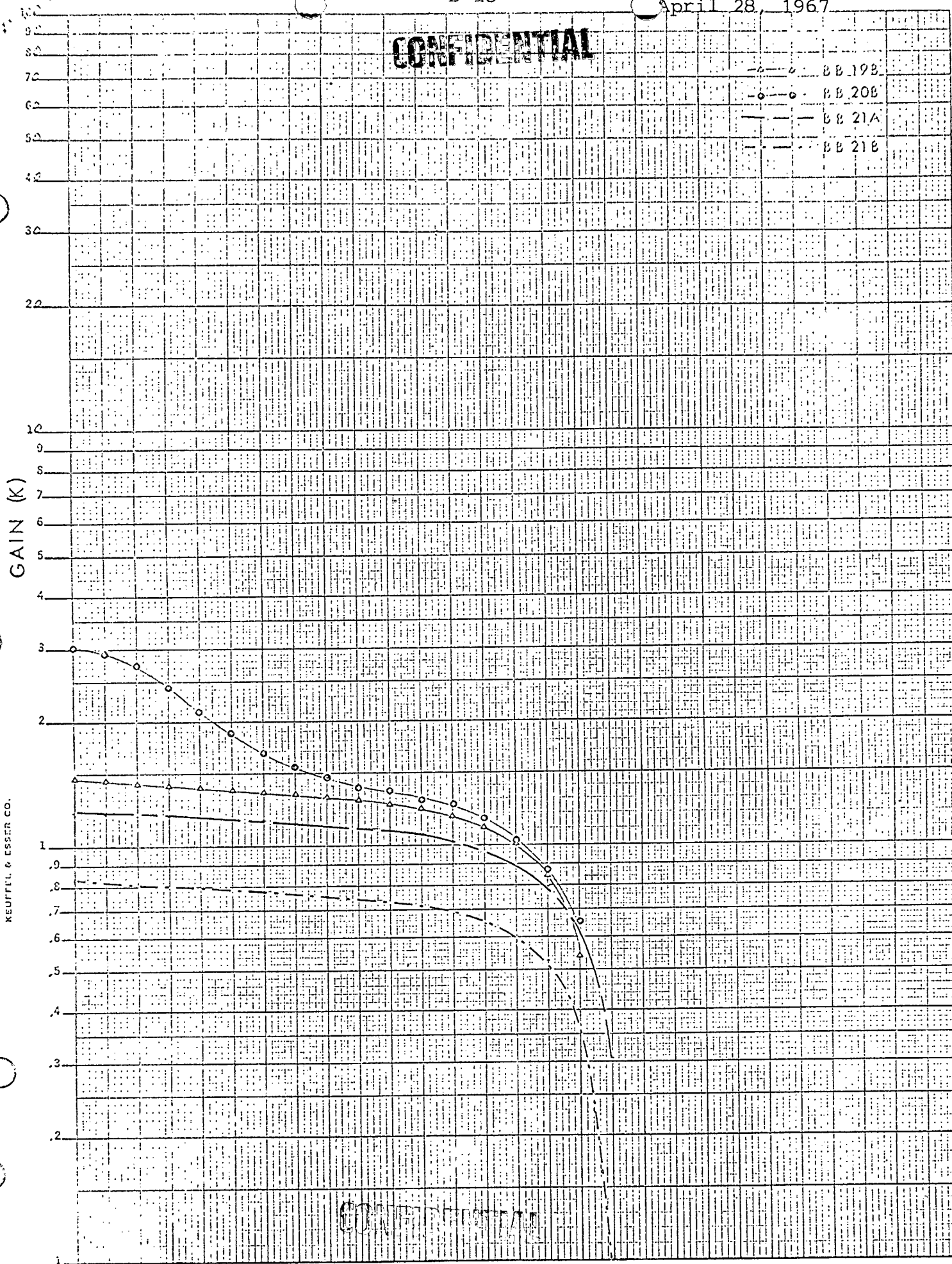
SUMMARY OF ANGULAR GAIN FUNCTIONS.

ANGLE K	BB-19B	BB-20B	BB-21A	BB-21B
0	1.45	3.04	1.2	.83
5	1.43	2.93	1.2	.82
10	1.42	2.72	1.13	.81
15	1.4	2.41	1.17	.8
20	1.38	2.12	1.16	.79
25	1.36	1.88	1.15	.79
30	1.35	1.7	1.14	.78
35	1.33	1.54	1.13	.77
40	1.31	1.45	1.11	.76
45	1.29	1.38	1.1	.74
50	1.26	1.35	1.09	.73
55	1.23	1.3	1.06	.71
60	1.17	1.24	1.02	.68
65	1.11	1.14	.97	.65
70	1.01	1.02	.9	.6
75	.85	.87	.79	.53
80	.54	.65	.63	.37
85	.06	.09	.3	.08
90	0	0	0	0

TS	.494	.5779	.445	.2925
T45	.197	.263	.166	.114
TSP	0	.0001	0	0
V45	.059	.375	.045	.052
ABS				

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April 28, 1967

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CONFIDENTIALReport No. P-19-21
Corning Glass Works
April 28, 1967

SUMMARY OF ANGULAR GAIN FUNCTIONS.

ANGLE °K	SAMPLE CODES			
	BB-22B	BB-23A	BB-23B	BB-26B
0	.84	.93	.63	.77
5	.84	.89	.63	.77
10	.83	.87	.62	.76
15	.82	.85	.62	.76
20	.81	.84	.61	.76
25	.8	.83	.61	.76
30	.8	.83	.6	.75
35	.79	.83	.6	.75
40	.78	.82	.6	.74
45	.76	.82	.59	.73
50	.74	.82	.58	.71
55	.72	.8	.57	.7
60	.69	.79	.55	.68
65	.65	.76	.52	.64
70	.59	.7	.49	.6
75	.49	.6	.44	.54
80	.33	.42	.36	.44
85	.05	.14	.12	.15
90	0	0	0	0
=====				
TS	.2925	.329	.238	.294
T45	.116	.122	.088	.11
TSP	0	0	0	0
V45	.05	.064	.033	.026

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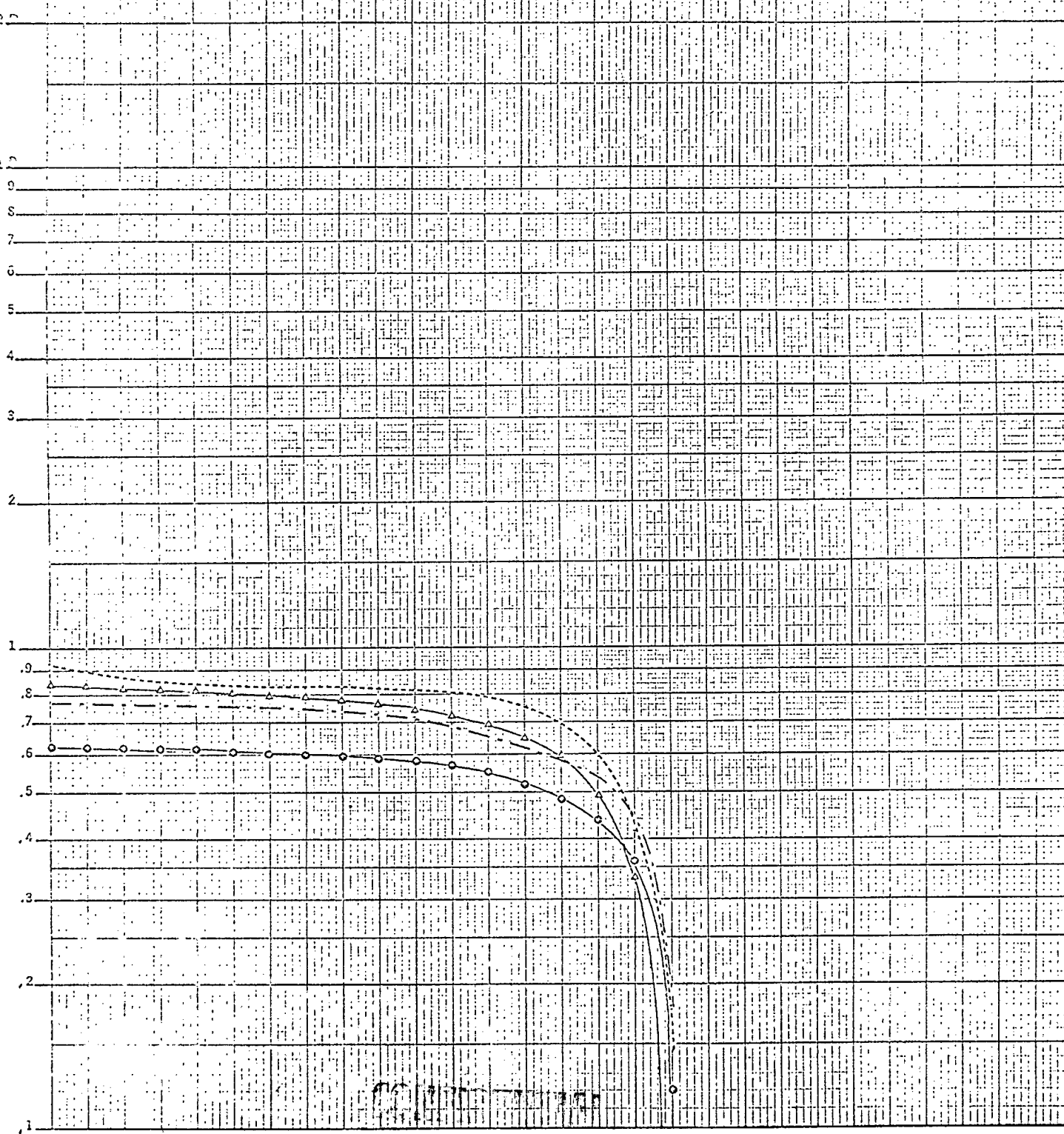
APR 11 28 1967

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BB 22B
BB 23A
BB 23B
BB 26B

GAIN (K)

46 5810
SEMI-LOGARITHMIC
3 CYCLES X 120 DIVISIONS
KEUFFEL & ESSER CO.



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Corning Glass Works
April 28, 1967

SUMMARY OF ANGULAR GAIN FUNCTIONS.

ANGLE K	SAMPLE CODES			
	BB-27A	BB-27B	BB-28A	BB-28B
0	1.23	.96	1.36	.89
5	1.22	.95	1.35	.88
10	1.2	.94	1.34	.87
15	1.19	.94	1.33	.86
20	1.17	.93	1.32	.85
25	1.16	.91	1.3	.84
30	1.15	.89	1.29	.84
35	1.13	.88	1.28	.84
40	1.12	.87	1.27	.84
45	1.1	.86	1.25	.84
50	1.08	.85	1.24	.83
55	1.06	.83	1.22	.81
60	1.01	.8	1.18	.78
65	.96	.76	1.13	.74
70	.89	.71	1.05	.69
75	.77	.63	.93	.62
80	.57	.46	.71	.44
85	.09	.14	.11	.09
90	0	0	0	0
=====				
TS	.432	.345	.5	.3295
T45	.168	.131	.189	.124
TSP	0	0	0	0
V45	.054	.051	.041	.032
ABS				

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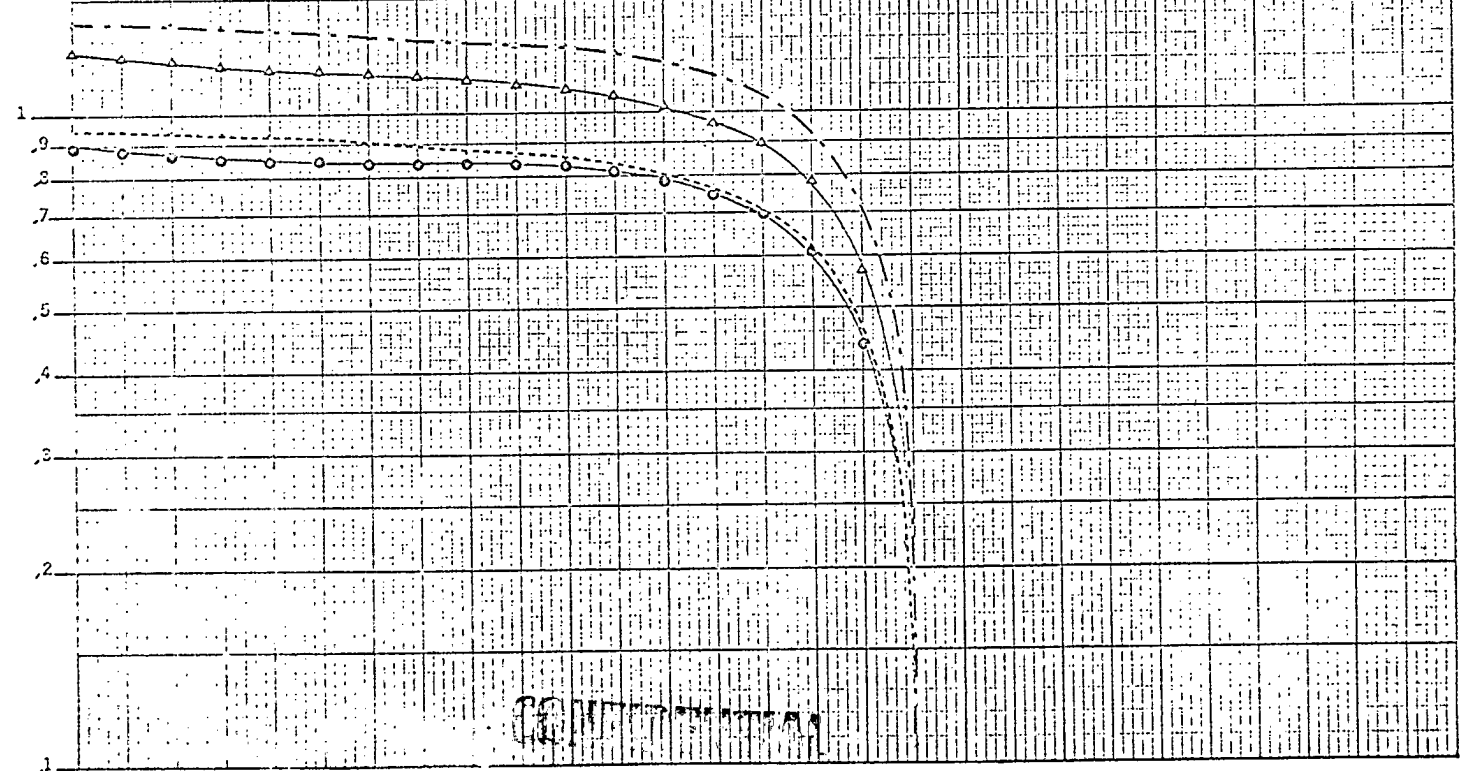
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BB 27A
BB 27B
BB 28A
BB 28B

GAIN (K)

MADE IN U.S.A.
KEUFEL & ESSER CO.



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April 28, 1967

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SUMMARY OF ANGULAR GAIN FUNCTIONS.

ANGLE K	SAMPLE CODES			
	BB-29A	BB-29B	BB-30A	BB-30B
0	1.51	.98	1.48	.95
5	1.38	.97	1.47	.94
10	1.36	.96	1.45	.94
15	1.35	.95	1.43	.93
20	1.34	.94	1.41	.92
25	1.32	.92	1.39	.91
30	1.31	.91	1.36	.9
35	1.29	.9	1.33	.89
40	1.28	.89	1.31	.89
45	1.27	.88	1.31	.88
50	1.25	.87	1.29	.86
55	1.22	.86	1.28	.84
60	1.18	.84	1.24	.82
65	1.12	.79	1.19	.78
70	1.04	.69	1.11	.73
75	.92	.57	.96	.65
80	.64	.4	.76	.49
85	.14	.06	.43	.25
90	0	0	0	0

TS	.5	.3415	.54	.3555
T45	.192	.134	.2	.132
TSP	0	0	0	0
V45	.039	.054	.064	.043

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GAIN (K)

BB 29A
BB 29B
BB 30A
BB 30B

46 5810
SEMICONDUCTOR
3 CYCLES X 140 DIVISIONS
KEUFFEL & ESSER CO.

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April 28, 1967

SUMMARY OF ANGULAR GAIN FUNCTIONS.

ANGLE K	BB-31A	SAMPLE CODES BB-40A	BB-40B	
0	1.26	.94	.74	0
5	1.25	.94	.73	0
10	1.24	.93	.72	0
15	1.23	.92	.72	0
20	1.22	.92	.71	0
25	1.21	.91	.7	0
30	1.2	.9	.69	0
35	1.19	.89	.68	0
40	1.18	.88	.67	0
45	1.17	.87	.65	0
50	1.15	.85	.64	0
55	1.13	.83	.62	0
60	1.09	.8	.59	0
65	1.03	.76	.56	0
70	.96	.71	.52	0
75	.85	.64	.46	0
80	.65	.5	.36	0
85	.34	.25	.16	0
90	0	0	0	0
=====				
TS	.473	.352	.2618	0
T45	.176	.132	.101	0
TSP	0	0	0	0
V45	.035	.041	.065	0

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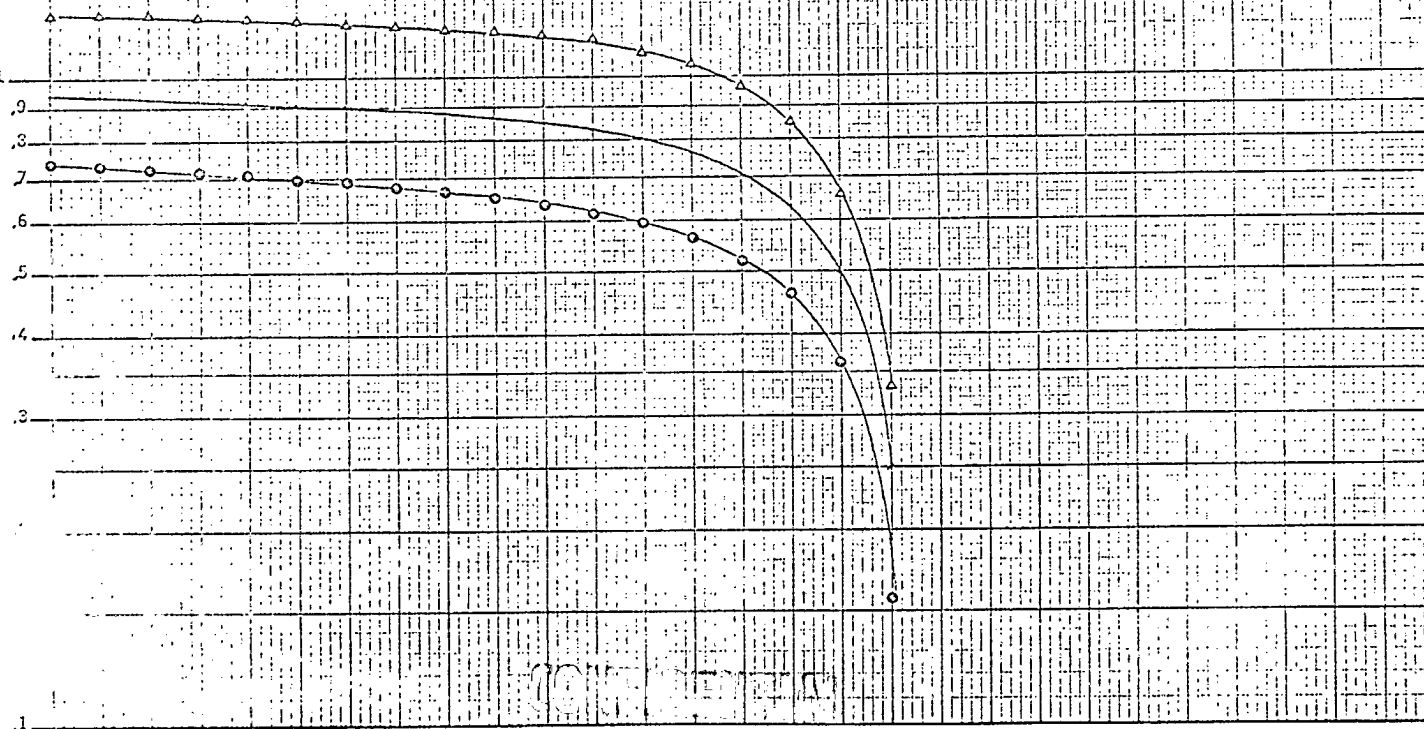
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BB 31A
BB 40A
BB 40B

GAIN (K)

4G 5510
MADE IN U.S.A.
KEUFFEL & ESSER CO.



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Corning Glass Works
April 28, 1967

SUMMARY OF ANGULAR GAIN FUNCTIONS.

ANGLE K	SAMPLE CODES			
	BC-1A	BC-1B	BC-1C	BC-1D
0	1.95	1.66	2.61	1.94
5	1.9	1.66	2.53	1.91
10	1.85	1.65	2.45	1.88
15	1.8	1.63	2.37	1.85
20	1.75	1.58	2.29	1.82
25	1.7	1.52	2.22	1.79
30	1.64	1.47	2.14	1.76
35	1.6	1.44	2.06	1.74
40	1.54	1.38	1.98	1.71
45	1.49	1.33	1.9	1.68
50	1.44	1.29	1.82	1.65
55	1.39	1.24	1.75	1.6
60	1.34	1.2	1.67	1.54
65	1.27	1.14	1.59	1.46
70	1.17	1.06	1.46	1.35
75	1.01	.93	1.17	1.16
80	.75	.73	.76	.78
85	.32	.33	.23	.15
90	0	0	0	0

TS	.5997	.5432	.7439	.657
T45	.241	.216	.313	.258
TSP	.0433	.0708	.0001	0
V45	.133	.11	.156	.072

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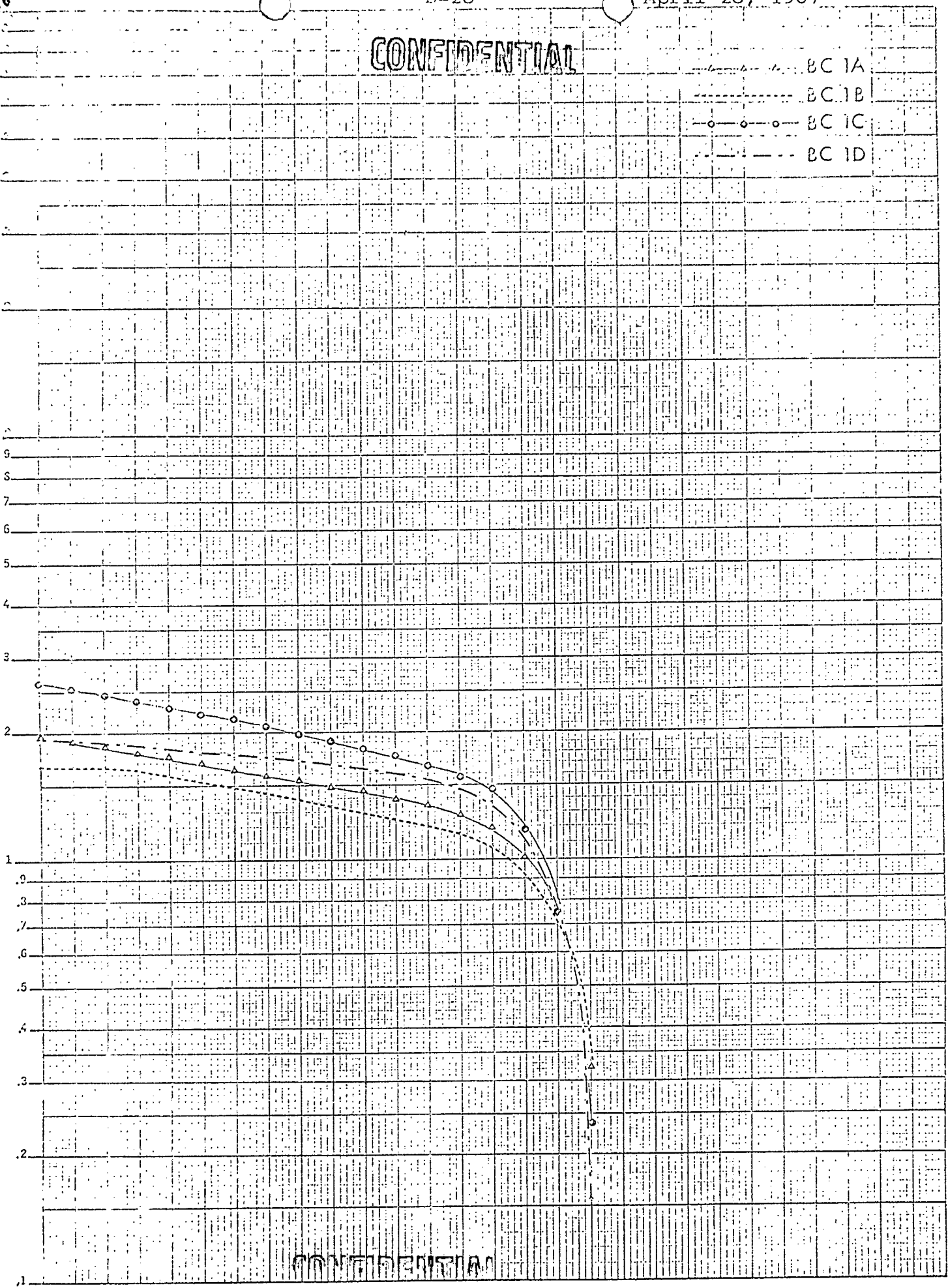
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BC 1A
BC 1B
BC 1C
BC 1D

GAIN (K)

4G 5310
PAGE 14 U.S.A.
KREFFEL & ESSER CO.



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